

Basis for new Claim 16 is submitted to be found in the application as filed at page 7, lines 3-9 and page 12, lines 8-12.

A version with markings to show changes made is attached.

We turn now to the action. Claims 4, 5 and 12 are indicated as being dependent on a rejected base claim but are indicated as being allowable if rewritten in independent form including all the limitations of the base claim and any intervening claims.

Claim 1 has been amended herewith to be Claim 12 rewritten in independent form including all the limitations of the base claim and any intervening claims. Therefore, Claim 1 as amended is allowable.

Claims 2, 3, 4, 5, 7, 8 and 9 depend directly or indirectly from allowable amended Claim 1. Therefore, Claims 2, 3, 4, 5, 7, 8 and 9 are allowable.

That leaves Claims 10, 11, 13, 14, 15 and 16.

Claims 1-3 and 6-11 are rejected under 35 U.S.C. 112, first paragraph as lacking enablement on the basis of citations that indicate a minor proportion of asthmatics may experience airway obstruction on treatment with applicant's disclosed regimen with H₂S. Claims 1-3 and 7-9 have been amended in a way that the action indicates, will avoid the rejection. Claim 6 has been canceled. Claims 10 and 11 are still subject to the rejection. Reconsideration is requested. It is submitted that the rejection should not apply to Claims 13-16.

35 U.S.C. 112, first paragraph, is reproduced below.

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person

skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

As indicated above, 35 U.S.C. 112 requires a description enabling a skilled person to make and use. In this case, there is no question of how to make--only a question of how to use. In this case, In re Hitchings, 144 U.S.P.Q. 637 (C.C.P.A. 1965) indicates an express disclosure of manner of administration and dosage, will satisfy the how to use requirement. These are clearly set forth for H₂S in the application as filed at page 12, lines 8-12. Thus, it is submitted that Claims 10, 11 and 13-16 meet the requirements of 35 U.S.C. 112, first paragraph.

The rejection is really based on an assertion of lack of utility and is brought under 35 U.S.C. 112 rather than 35 U.S.C. 101. See MPEP Section 2164.07.

The requirements for utility are set forth in the PTO utility guidelines; see MPEP Section 2107.

Rejections for lack of utility have to do with burdens. Initially, the burden is on the examiner to show that one of ordinary skill in the art would reasonably doubt the asserted utility. See MPEP Section 2164.07(I)(B). The examiner has tried to meet this burden by citing documents which show that a minor proportion of asthmatics may experience airway obstruction with applicant's disclosed regimen with H₂S.

It is submitted that the examiner has not met the required burden because the documents are equivocal.

Moreover, the cited documents are not pertinent to new claims 14-16 since documents are directed to lack of utility for treating asthma and Claims 14-16 exclude treatment of asthma.

Even if the PTO is considered to have met its burden for Claims 10, 11 and 13, it is

submitted that the equivocal documents are negated by documents enclosed herewith and thus the burden again switches to the PTO.

Consider the following documents.

Consider firstly, Hawley's Condensed Chemical Dictionary, 11th Edition (1987), pages 618 and 1154, copy attached. These indicate a threshold limit value (TLV) for H₂S of 10 ppm in air. This means that workers may be repeatedly exposed to 10 ppm H₂S without adverse effects.

Consider also a printout obtained from the Internet on 6/1/03 of Affinity Laboratory Technologies Public Exposure Guidelines, copy attached, which confirms a TLV of 10 ppm or 15 ppm for H₂S.

Consider also Agency for Toxic Substances and Disease Registry ToxFAQs™ for Hydrogen Sulfide (June 1999), copy attached, which indicates OSHA has established an acceptable concentration of 20 ppm in the workplace.

Consider also a pamphlet by Illinois Department of Public Health titled "Hydrogen Sulfide Gas" which indicates that at levels of 250 ppm, recovery occurs quickly if exposure is ended promptly.

It is submitted that since workers may be acceptably exposed to 10 ppm repeatedly on a long term basis and since OSHA has established an acceptable concentration of 20 ppm in the workplace, then Claim 13 with an upper limit of 10 ppm should certainly be acceptable even for asthmatic subjects.

Note further, that the 10 and 20 ppm limits are for long term exposure. It is submitted that 100 ppm (Claims 10 and 11) would be reasonable for the shorter time exposures contemplated by the invention. See Example X which indicates an improvement from FEV of 1.5

to FEV of 1.8 at 10 ppm “over the following day”.

Consider further that the TLV and OSHA limits are for H₂S in air wherein Claims 10, 11 and 13 required H₂S in nitrogen. While the patient would be breathing air at the same time as being administered H₂S in nitrogen, the air would reduce the concentration of H₂S in the lungs and the H₂S would less likely oxidize, e.g., to sulfuric acid, when administered in H₂S compared to when administered in air.

The statement in the action that “Air exposure would be a lot less detrimental than direct delivery into the lungs” is noted. It is submitted that this position is inappropriate. It is clear from the above that the concentration of H₂S is the important factor. It is submitted that the concentration of H₂S would not be expected to be reduced from nose to trachea compared to introduction at the trachea.

Consider further that even if difficulties would ensue for a minor proportion of asthmatics, this should not penalize the asthmatics who would benefit from the treatment. Most drugs effect difficulties in some proportion of subjects to which they are administered and yet are recognized as being important for treatment. One skilled in the art would know that in those cases where difficulties ensue, the treatment is discontinued.

Consider that the PDR says about Celebrex®:

A patient with symptoms and/or signs suggesting liver dysfunction, or in whom an abnormal liver test has occurred, should be monitored carefully for evidence of the development of a more severe hepatic reaction while on therapy with Celebrex®. If clinical signs and symptoms consistent with liver disease develop, or if systemic manifestations occur (e.g. eosinophilia, rash etc.), Celebrex® should be discontinued.

This scenario is also the case for treatments causing lung obstruction. In this regard,


consider that acetylcysteine is an FDA approved drug for use as a mucolytic for cystic fibrosis patients despite the fact that in some patients, mucolytics may aggravate airway obstruction. In those cases, the offending regimen is discontinued and another regimen implemented. See the Merck Manual 17th Edition, pages 513 and 514, copy enclosed with last response.

Obviously, one skilled in the art would discontinue H₂S treatment in those some cases where there would be a problem. This is submitted not to be grounds for disparaging the invention of negating patentability.

Allowance of all claims is requested.

Respectfully submitted,

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Case Duke File 1661 CIP

Date: June 5, 2003

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claim 1 has been amended as follows:

1. (Amended) A method for treating a pulmonary disorder associated with depletion of the S-nitrosogluthathione pool in the lung or depletion of the glutathione pool in the lung or production of reactive oxygen species in the lung in a patient having such disorder which comprises delivering into the lungs of said patient as a gas, a therapeutically effective amount of an agent, which causes repletion or increase of the S-nitrosogluthathione pool in the lung or protects against toxicity where glutathione is depleted in the lung or where reactive oxygen species are increased in the lung and does so independently of reaction with oxygen, with the proviso that said agent does not comprise H₂S.

Claim 6 has been canceled.

Claim has been amended as follows:

10. (Amended) A [The] method [of Claim 6] for treating a pulmonary disorder associated with depletion of the S-nitrosogluthathione pool in the lung or depletion of the glutathione pool in the lung or production of reactive oxygen species in the lung in a patient having such disorder which comprises delivering into the lungs of said patient as a gas, a therapeutically effective amount of an agent, which causes repletion or increase of the S-nitrosogluthathione pool in the lung or protects against toxicity where glutathione is depleted in the lung or where reactive oxygen species are increased in the lung and does so independently of reaction with oxygen, with the proviso that when said agent comprises H₂S, [where] the H₂S is

administered at a dosage of 0.1 to 100 ppm in nitrogen.

Claim 12 has been canceled..

Claims 13-16 have been added as follows:

--13. The method of Claim 10 where the H₂S is administered at a dosage of 0.1 to 10 ppm in nitrogen.

--14. A method for treating a pulmonary disorder associated with depletion of the S-nitrosogluthathione pool in the lung or depletion of the glutathione pool in the lung or production of reactive oxygen species in the lung in a patient having such disorder which comprises delivering into the lungs of said patient as a gas, a therapeutically effective amount of an agent, which causes repletion or increase of the S-nitrosogluthathione pool in the lung or protects against toxicity where glutathione is depleted in the lung or where reactive oxygen species are increased in the lung and does so independently of reaction with oxygen, with the proviso that said pulmonary disorder is not asthma.

--15. The method of Claim 14 where the disorder is selected group consisting of pulmonary hypertension including persistent pulmonary hypertension of the newborn, adult respiratory distress syndrome, pneumonia, interstitial lung diseases including pulmonary fibrosis, and cystic fibrosis.

--16. The method of Claim 15 where the agent comprises H₂S.--

Hawley's Condensed Chemical Dictionary

ELEVENTH EDITION

Revised by

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and
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VAN NOSTRAND REINHOLD COMPANY

New York

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Library of Congress Catalog Card Number: 86-23333
ISBN: 0-442-28097-1

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Printed in the United States of America

Van Nostrand Reinhold Company Inc.
115 Fifth Avenue
New York, New York 10003

Van Nostrand Reinhold Company Limited
Molly Millars Lane
Wokingham, Berkshire RG11 2PY, England

Van Nostrand Reinhold
480 Latrobe Street
Melbourne, Victoria 3000, Australia

Macmillan of Canada
Division of Canada Publishing Corporation
164 Commander Boulevard
Agincourt, Ontario M1S 3C7, Canada

15 14 13 12 11 10 9 8 7 6 5 4 3

Library of Congress Cataloging-in-Publication Data

Condensed chemical dictionary.
Hawley's condensed chemical dictionary.

Rev. ed. of: The Condensed chemical dictionary.
10th ed./rev. by Gessner G. Hawley, 1981.

I. Chemistry—Dictionaries. I. Hawley, Gessner
Goodrich, 1905— II. Sax, N. Irving (Newton Irving)
III. Lewis, Richard J., Sr. IV. Title.
QD5.C5 1987 540'.3'21 86-23333
ISBN 0-442-28097-1

gases. Large quantities of hydrogen are necessary.

See also gasification, hydrogenation.

hydrogen peroxide. CAS: 7722-84-1. H_2O_2 (molecular formula), $\text{H}-\text{O}-\text{O}-\text{H}$ (structural formula).

Properties: (pure anhydrous) Density of solid, 1.71 g/cc, density of liquid 1.450 g/cc at 20°C, viscosity, liquid 1.245 centipoise, surface tension 80.4 dynes/cm at 20°C, fp -0.41°C , bp 150.2°C , soluble in water and alcohol. (Solutions): Pure hydrogen peroxide solutions, completely free from contamination, are highly stable; a low percentage of an inhibitor such as acetanilide or sodium stannate, is usually added to counteract the catalytic effect of traces of impurities such as iron, copper, and other heavy metals. A relatively stable sample of hydrogen peroxide typically, decomposes at the rate of approximately 0.5% per year at room temperature.

Derivation: (a) autoxidation of an alkyl anthrahydroquinone such as the 2-ethyl derivative in a cyclic continuous process in which the quinone formed in the oxidation step is reduced to the starting material by hydrogen in the presence of a supported palladium catalyst; (b) by electrolytic processes in which aqueous sulfuric acid or acidic ammonium bisulfate is converted electrolytically to the peroxydisulfate, which is then hydrolyzed to form hydrogen peroxide; (c) by autoxidation of isopropyl alcohol. Method (a) is most widely used.

Grade: USP (3%), technical (3, 6, 27.5, 30, 35, 50, and 90%), FCC. Most common commercial strengths are 27.5, 35, 50, and 70%.

Hazard: Dangerous fire and explosion risk, strong oxidizing agent. Concentrated solutions are highly toxic and strongly irritating. TLV: 1 ppm in air.

Use: Bleaching and deodorizing of textiles, wood pulp, hair, fur, etc.; source of organic and inorganic peroxides; pulp and paper industry; plasticizers; rocket fuel; foam rubber; manufacture of glycerol; antichlor; dyeing; electroplating; antiseptic; laboratory reagent; epoxidation, hydroxylation, oxidation, and reduction; viscosity control for starch and cellulose derivatives; refining and cleaning metals; bleaching and oxidizing agent in foods; neutralizing agent in wine distillation; seed disinfectant; substitute for chlorine in water and sewage treatment.

hydrogen phosphide. See phosphine.

hydrogen, phosphoretted. See phosphine.

hydrogen selenide. CAS: 7783-07-5. H_2Se . Properties: Colorless gas; soluble in water, carbon disulfide, phosgene; bp -42°C ; fp -64°C ; d 2.00 (air = 1).

Grade: 98% pure.

Hazard: Dangerous fire and explosion risk; reacts violently with oxidizing materials. Toxic by inhalation, strong irritant to skin, damaging to lungs and liver. TLV: 0.05 ppm (as selenium) in air.

Use: Preparation of metallic selenides and organoselenium compounds; in doping as mix for preparation of semiconductor materials containing controlled amounts of significant impurities.

hydrogen slush. A mixture of solid and liquid hydrogen at the hydrogen triple point 13.8°K and 1.02 psia. It is denser and less hazardous than liquid hydrogen.

hydrogen sulfide. (sulfuretted hydrogen).

CAS: 7783-06-4. H_2S .

Properties: Colorless gas, offensive odor, soluble in water and alcohol, d 1.189 (air = 1.00), fp -83.8°C , bp -60.2°C , sp vol 11.23 cu ft/lb (21.1°C , 1 atm), autoign temperature 500°F (260°C).

Derivation: (a) By the action of dilute sulfuric acid on a sulfide, usually iron sulfide; (b) by direct union of hydrogen and sulfur vapor at a definite temperature and pressure; (c) as a byproduct of petroleum refining.

Grade: Technical 98.5%, purified 99.5% min, CP.

Hazard: Highly flammable, dangerous fire risk, explosive limits in air 4.3–46%. Toxic by inhalation, strong irritant to eyes and mucous membranes. TLV: 10 ppm in air.

Use: Purification of hydrochloric acid and sulfuric acid, precipitating sulfides of metals, analytical reagent, source of sulfur and hydrogen.

hydrogen tellurate. See telluric acid.

hydrogen telluride. CAS: 7783-09-7. H_2Te . Properties: Colorless gas, d (liquid): 2.57 (-20°C), fp -49°C , bp -2°C , soluble in water but unstable, soluble in alcohol and alkalis.

Hazard: See hydrogen selenide.

hydrol. See tetramethyldiaminobenzhydrol.

hydrolase. (hydrase). An enzyme which catalyzes the removal of water from the substrate. See enzyme.

"Hydrolin."TM TM for an ammonium nitrate base blasting agent which requires specially constructed primers for detonation.

Use: For seismic prospecting at sea.

Hazard: See ammonium nitrate.

hydroliquefaction. Production of liquid hydrocarbon fuels by hydrogenation of coal. See gasification; Oil/Gas Process.

hydrolube. A water-glycol base noncombustible hydraulic fluid.

hydrolysis. A chemical reaction in which a compound reacts with another compound, usually water, to form more new substances. For example, the hydrolysis of a compound $\text{HOH} \rightarrow \text{CH}_3\text{COOH}$ is the conversion of starch to glucose in the presence of sucrose (cane sugar) by reaction with zyme or acid. Fats react with water in the presence of an enzyme to form various products, etc.

hydrometer. Device for measuring the density of liquids. See also Baume.

hydronium ion. H_3O^+ . A cation formed by the transfer of a proton from a molecule of water (OH^-) is also formed. It is also called hydronium ion. It is relatively rare, resulting from the reaction of water molecules in a solution.

hydroperoxide. A peroxide in which one of the oxygen atoms is bonded to a hydrogen atom. Generalized for hydroperoxide, hydroperoxide, oxidizing agent, and peroxide of higher molecular weight. Hydroperoxides are used as oxidizing agents in the production of hydrocarbons and peroxide in a variety of reactions.

hydrophilic. Having the ability to absorb water, or to be mixed with water. The formation of reversible emulsions of water in oil, gums, pectins, and other substances.

hydrophobic. Having the ability to repel water, or to be mixed with oil. It is the ability of all oils, waxes, and other substances to repel water and form black and white emulsions.

hydroponics. The method of growing plants in water.

"Hydro-Pruf." A trademark for a product used for fabricating and curing temperature-resistant materials.

hydroquinol. A chemical compound used in the production of synthetic rubber and in the treatment of skin diseases.

$\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{NH}_2)\text{COOH}$. An essential amino acid.

Properties: Colorless crystals, soluble in water, optically active. dl-threonine, mp 228–229°C with decomposition; l(-)-threonine (naturally occurring), mp 255–257°C with decomposition; dl-allo-threonine, mp 250–252°C.

Derivation: Hydrolysis of protein (casein), organic synthesis.

Use: Nutrition and biochemical research, dietary supplement.

threshold limit value. (TLV). A set of standards established by the American Conference of Governmental Industrial Hygienists for concentrations of airborne substances in workroom air. They are time-weighted averages based on conditions which it is believed that workers may be repeatedly exposed to day after day without adverse effects. The TLV values are revised annually and provide the basis for the safety regulations of OSHA. They are intended to serve as guides in control of health hazards, rather than definitive marks between safe and dangerous concentration. In this book, these are indicated by "TLV."

See also air pollution.

thrombin. A proteolytic enzyme which catalyzes the conversion of fibrinogen to fibrin and thus is essential in the clotting mechanism of blood. It is present in the blood in the form of prothrombin under normal conditions; when bleeding begins, the prothrombin is converted to thrombin, which in turn activates the formation of fibrin.

thrombocyte. See platelet.

thromboxane. See prostaglandin.

throwing oil. An oil applied to prepare raw silk and filament rayon for "throwing," the operation by which the filaments are twisted into threads. Applied by a bath, the oils condition the filaments and yarns for subsequent weaving or knitting. Usually compounded to be self-emulsifying and may contain a sizing agent such as dextrin, gelatin, etc.

See also slashing compound.

throwing power. A term denoting the effectiveness of an electrolytic cell for depositing metal uniformly over a surface being electroplated, particularly in irregular and recessed areas. The throwing power is the weight of deposition per unit distance between the electrodes.

THPC. See tetrakis(hydroxymethyl)phosphonium chloride.

thuja oil. (arbor vitae oil). CAS: 8007-20-3. Properties: Pale yellow essential oil, camphor-like odor, d 0.910–0.920, refr index 1.459 (20°C), optical rotation –10 to –13 degrees in 100 mm tube. Soluble in alcohol, ether, chloroform, carbon disulfide, fixed oils, and mineral oil. Combustible. Chief known constituents: Dextro-pinene, levofenchone, thujone, should contain more than 60% ketones calculated as thujone. Derivation: Distilled from the leaves of the white cedar, *Thuja occidentalis*.

Grade: Technical, FCC (as cedarleaf oil).

Use: Perfumery, flavoring.

thujone. CAS: 546-80-5. $\text{C}_{10}\text{H}_{16}\text{O}$. A terpene-type ketone contained in thuja oil and the oils of sage, tansy, and wormwood. Properties: Colorless liquid, d 0.915–0.919 (20/20°C), bp 203°C, insoluble in water, soluble in alcohol. Combustible. Hazard: Toxic by ingestion. Use: Solvent.

thulia. See thulium oxide.

thulium. CAS: 7440-30-4. Tm. Atomic number 69, Group IIIB of the periodic table, a rare earth element of the lanthanide groups, aw 168.9342, valence = 3, no stable isotopes. Properties: Metallic luster, reacts slowly with water, soluble in dilute acids, salts colored green, d 9.318, mp 1550°C, bp 1727°C. Derivation: Isolated by reduction of the fluoride with calcium. See rare earth minerals. Grade: Regular high purity (ingots, lumps). Hazard: Fire risk in form of dust. Use: Ferrites, x-ray source.

thulium 170. Radioactive thulium of mass number 170. Use: X-ray source in portable units.

thulium chloride. $\text{TmCl}_3 \cdot 7\text{HOH}$. Properties: Green, deliquescent crystals; mp 824°C; bp 1440°C; very soluble in water and alcohol.

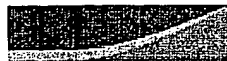
thulium oxalate. $\text{Tm}_2(\text{C}_2\text{O}_4)_3 \cdot 6\text{HOH}$. Properties: Greenish-white precipitate, loses H_2O at 50°C, soluble in aqueous alkali oxalates. Derivation: Precipitation of a solution containing a thulium salt and a mineral acid by addition of oxalic acid. Use: Analytical separation of thulium (and other rare-earth metals) from the common metals.

thulium oxide. (thulia). Tm_2O_3 . Properties: Dense white powder with greenish tinge, slightly hygroscopic, absorbs water and

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Hydrogen Sulfide

Oral Toxicity Tests Diagnostic Tests

Hydrogen Sulfide and Public Exposure Guidelines

Public Exposure Guidelines

<http://www.nwn.noaa.gov/sites/hazmat/cameo/locs/expguide.html>

When a chemical spill occurs near a population center, responders establish a level of concern (LOC) that will protect the general public from exposure.

Public exposure guidelines are meant to protect all segments of the population, including the very young and the very old, pregnant women, and hypersensitive individuals. However, relatively few public exposure guidelines have been developed. Spill responders commonly use occupational standards and their own best judgment to select a LOC protective enough for the general population.

This article briefly discusses the main features of available public exposure guidelines.

NAAQS

The National Ambient Air Quality Standards (NAAQS) were developed by the U.S. Environmental Protection Agency (EPA) for six air pollutants: ozone, nitrogen dioxide, sulfur dioxide, particulates, lead, and carbon monoxide. These limits were designed to protect the whole population all the time. Some have a 24-hour excursion limit, which may be exceeded only once a year.

While conservative and protective, these standards are not appropriate for emergency response. The substances covered are common air pollutants generated mostly by burning fuel, not toxic chemicals that accidentally spill and create a short-term emergency. In addition, the shortest NAAQS exposure duration is 24 hours,

TOPAS 1 & 2
 Halitox
 Bacterial Toxins
 Periodontal Bacteria
 Toxic Root Canals
 ALT News
 RCT & Implants
 GCF Testing
 Test Enzymes
 Toxin Detection
 Beyond The Mouth
 Systemic Diseases
 Periodontal Disease
 Toxins & Disease
 Focal Infection
 Yeast & Fungi
 RCT Reasoning
 Cavitation Overview
 Studies & Links
 Find A Dentist
 Distributors
 Better Root Canals
 Forms & Protocols
 Dr. Price & RCT
 Dr. Meinig & RCT
 Culturing Bacteria
 Antioxidants
 Hydrogen Sulfide
 Oral Microbiology
 Homeopathy
 Sterile Root Canals

while exposure from an accidental spill is usually no longer than 1 hour.

1/10 IDLH

This exposure limit was suggested for use as a public exposure guideline by EPA, the Federal Emergency Management Agency (FEMA), and the Department of Transportation (DOT) in the guidance document, Technical Guidance for Hazard Analysis, because it was recognized that the Immediately Dangerous to Life and Health (IDLH) limits may not be applicable for general public exposure. The choice of 1/10 of the IDLH is based on reducing the IDLH by one order of magnitude, thus providing a safety factor. Nevertheless, it is an extrapolation that may or may not be justified. Many IDLH values were made more protective in 1994. In some cases, this may create a situation in which adhering to 1/10 of the new IDLH makes the LOC lower than the commonly used occupational exposure limits such as the Threshold Limit Values (TLV) or Permissible Exposure Limits (PEL). Both of these are exposure limits deemed acceptable for most adults for an 8-hour workday, for a lifetime of employment.

ERPG

The Emergency Response Planning Guidelines (ERPG) were developed under the guidance of a committee within the American Industrial Hygiene Association. It is a three-tier standard with one common denominator, a 1-hour contact duration (figure 1). Each standard identifies the substance, its chemical and structural properties, animal toxicology data, human experience, existing exposure guidelines, the ratio behind the selected value, and a list of references.

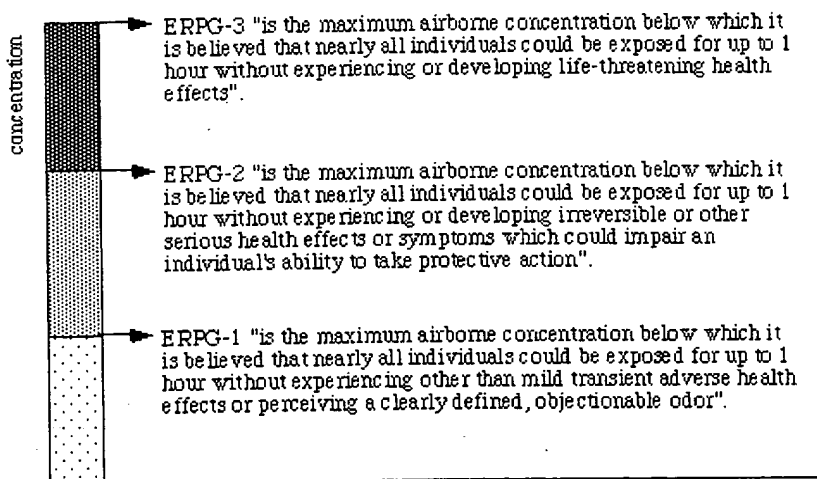


FIGURE 1. The three-tiered ERPG public exposure guidelines. The definitions and format are from the ERPG publication.

The ERPG standard does not protect everyone. Hypersensitive individuals would suffer adverse reactions to concentrations far below those suggested in the standard. In addition, ERPG, like other exposure guidelines, is based mostly on animal studies, thus raising the question of applicability to humans. The standard is focused on a period of time: 1 hour. Exposure in the field may be longer or shorter. However, the ERPG committee strongly advises against trying to extrapolate ERPG values to longer

periods of time.

The most important point to remember about the ERPG is that it does not contain safety factors usually incorporated into exposure standards such as the TLV. Rather, it estimates how the general public would react to chemical exposure. At the ERPG for example, most people would detect the chemical and may have temporary mild effects. At ERPG-3, on the other hand, it is estimated that the effects would be severe, although not life-threatening. The TLV, however, includes a safety factor to prevent ill effects. The ERPG should serve as a planning tool, not a standard to protect the public. You can view the current ERPG list at http://tis-hq.eh.doe.gov/web/Chem_Safety/teel.html.

In comparison to other LOCs, the ERPG is clearly defined and is based on extensive current data. The rationale for selecting each value is explained and other pertinent information is also provided. But at the present time, ERPG standards have been defined for fewer than 100 chemicals.

AEGL

Acute Exposure Guideline Levels (AEGLs) are under development by the National Research Council's Committee on Toxicology. The committee developed detailed guidelines for developing uniform, meaningful emergency response standards for the general public. The criteria in the guidelines take into account sensitive individuals and are meant to protect nearly all people. The committee has begun putting the guidelines into practice in developing AEGLs for specific chemicals. As of mid-2001, defined AEGL values for four chemicals have been released; proposed AEGL values for more chemicals are under review. The committee's objective is to define AEGLs for the 300+ extremely hazardous substances listed in Title III of the Superfund Amendment and Reauthorization Act (the US EPA offers an [online list of these substances](#)). The guidelines define three-tiered AEGLs as follows:

- ◆ AEGL 1: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
- ◆ AEGL 2: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or serious, long-lasting adverse health effects or an impaired ability to escape.
- ◆ AEGL 3: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Each of the three levels of AEGL--AEGL-1, AEGL-2, and AEGL-3, are developed for each of five exposure periods: 10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours.

AEGLs, when available, may be the best choice to use as LOC. However, personal judgment and experience should be used both for selecting an LOC and for interpreting the data obtained from using it.

AEGL values for four chemicals are shown and discussed in [Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 1 \(2001\)](#). The guidelines for developing AEGLs are described in [Standing Operating Procedures for Developing Acute Exposure Guideline Levels for Hazardous Chemicals](#).

Table 1 presents the major exposure guidelines now in use. Table 2 compares the values found in several guidelines for four chemicals which are commonly encountered during spill response.

TABLE 1. Summary of the major exposure standards.

Guideline	Target Group	Organization	Definition	Exposure Duration
AEGL	Public	COT NRC	Three-tier guideline for emergency response	10 min., 30 min, 1 hr, hr., and 8 hr
ERPG	Public	AIHA	Three-tier planning guideline for emergency response	1 hour
1/10 IDLH	Public	EPA/FEMA/DOT	LOC estimation based on IDLH	30 minutes
IDLH	Worker	NIOSH	Highest concentration from which escape possible without permanent damage	Used to be 30 minute The revised IDLH (1994) mentions no exposure duration.
TLV, PEL, REL	Worker	ACGIH, OSHA, NIOSH	Occupational exposure for 8-hour workday	8 hours per day, 20 to 30 years
STEL	Worker	ACGIH	Occupational short-term exposure limit	15 minutes

TABLE 2. Comparison of suggested exposure limits for four hazardous chemicals. Concentrations are in parts per million (ppm).

Chemical	ERPG-2	1/10 IDLH (numbers in parentheses are pre-1994 version)	IDLH (numbers in parentheses are pre-1994 version)	TLV-TWA	TLST
Ammonia	200	30 (50)	300 (500)	25	35
Chlorine	3	1 (3)	10 (30)	0.5	1
Hydrogen Sulfide	30	10 (30)	100 (300)	10	15
Sulfur Dioxide	3	10 (10)	100 (100)	2	5

EEGL

Emergency Exposure Guidance Levels (EEGLs) were developed by the National Research Council Committee on Toxicology for the Department of Defense (DOD) planning operations under emergency conditions such as spills, fires, and other contamination. Exposure duration was set at 1 to 24 hours. The exposures allowed are not safe but tolerable, and temporary effects are tolerated. The EEGLs were developed for young, healthy military personnel, so the same logic that applies to

IDLH applies to EEGLs: exposure that may be a nuisance to a young and healthy adult may be a real problem for a compromised individual. EEGL standards were developed for 41 substances, some of them used almost exclusively by the military.

SPEGL

The Short-term Public Exposure Guidance Levels (SPEGL) were developed by the I COT as public exposure guidelines, mostly for civilian populations around military bases (which are similar to civilian populations anywhere else). Effects were considered for all groups of the public. Only five SPEGLs have been developed: hydrazine, dimethylhydrazine, monomethyl hydrazine, nitrogen dioxide, and hydrogen chloride.

While applicable to spill response situations, the short list of SPEGLs covers only a small fraction of the large number of chemicals that may spill and pose a risk to the public.

TEEL

TEELs are temporary LOCs similar to ERPGs, and defined by the U.S. Department of Energy for use when ERPGs aren't available. Like ERPGs, they do not incorporate safety factors. Rather, they are designed to represent the predicted response of members of the general public to different concentrations of a chemical during an incident. Also like ERPGs, TEELs are three-tiered:

- ◆ TEEL-1 predicts irritation and other minor effects.
- ◆ TEEL-2 predicts irritating but reversible effects.
- ◆ TEEL-3 predicts serious impact, perhaps death of compromised individuals.

TEELs are derived according to a specific, standard methodology. Unlike the ERPG which are derived from extensive reviews of animal and human studies, the TEEL methodology prescribes using the ERPG when available, and when no ERPG exists using available LOCs and manipulating current data using a peer-reviewed, approved procedure. As a result, TEELs are available for many chemicals (published TEELs are listed at http://tis-hq.eh.doe.gov/web/Chem_Safety/teel.html).

The TEEL methodology can be used to derive a LOC for almost any chemical, but the power of TEELs is not as substantial as ERPGs. Nevertheless, TEELs can provide a useful reference when no other LOC is available.

Conclusions

No single exposure guideline adequately addresses the need for a LOC applicable to the general population during an emergency response situation. ERPG, which was designed for emergency response, provides useful planning guidelines, but for a limited number of substances. AEGLs provide the framework for developing public emergency response guidelines, but actual standards are just beginning to be available. Until adequate emergency response standards for a larger number of substances are available, emergency responders will continue to use existing guidelines and standards and their own best judgment when selecting the level of concern for emergency response incidents.

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Hydrogen Sulfide

CAS# 7783-06-4**June 1999**

This fact sheet answers the most frequently asked health questions about hydrogen sulfide. For more information, you may call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Hydrogen sulfide occurs naturally and is also produced by human activities. Just a few breaths of air containing high levels of hydrogen sulfide gas can cause death. Lower, longer-term exposure can cause eye irritation, headache, and fatigue. This substance has been found in at least 24 of the 1,467 National Priorities List sites identified by the Environmental Protection Agency (EPA).

**What is hydrogen sulfide?
(Pronounced hi'dro-gen sul'fide)**

Hydrogen sulfide occurs naturally in crude petroleum, natural gas, volcanic gases, and hot springs. It can also result from bacterial breakdown of organic matter. It is also produced by human and animal wastes.

Hydrogen sulfide can also result from industrial activities, such as food processing, coke ovens, kraft paper mills, tanneries, and petroleum refineries.

Hydrogen sulfide is a colorless, flammable gas under normal conditions. It is commonly known as hydrosulfuric acid, stink damp, and sewer gas. It smells like rotten eggs. People can smell it at low levels.

What happens to hydrogen sulfide when it enters the environment?

- Hydrogen sulfide is released primarily as a gas and will spread in the air.
- When released as a gas, it will form sulfur dioxide and sulfuric acid in the atmosphere.
- Sulfur dioxide can be broken down further and is a major component in acid

rain.

- Hydrogen sulfide remains in the atmosphere for about 18 hours.
- In some instances, it may be released as a liquid waste from an industrial facility.

How might I be exposed to hydrogen sulfide?

- You can be exposed by crude petroleum, natural gas, volcanic gases, and hot springs.
- You can be exposed at work if you work in the petroleum refining, petrochemical, or natural gas industry; food processing; wastewater treatment; coke oven plants; tanneries; or pulp and paper mills.
- A small amount of hydrogen sulfide is produced by bacteria in your mouth and gastrointestinal tract and by enzymes in your brain and muscle.

How can hydrogen sulfide affect my health?

Hydrogen sulfide is considered a broad-spectrum poison, meaning it can poison several different systems in the body.

Breathing very high levels of hydrogen sulfide can cause death within just a few breaths. There could be loss of consciousness after one or more breaths.

Exposure to lower concentrations can result in eye irritation, a sore throat and cough, shortness of breath, and fluid in the lungs. These symptoms usually go away in a few weeks. Long-term, low-level exposure may result in fatigue, loss of appetite, headaches, irritability, poor memory, and dizziness.

Animal studies showed that pigs that ate food containing hydrogen sulfide had diarrhea after a few days and weight loss after about 105 days.

How likely is hydrogen sulfide to cause cancer?

Hydrogen sulfide has not been shown to cause cancer in humans. Its ability to cause cancer in animals has not been studied fully. The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), and the EPA have not classified hydrogen sulfide for carcinogenicity.

How does hydrogen sulfide affect children?

Because it is heavier than air, hydrogen sulfide tends to sink, and because children are shorter than adults, they may be more likely to be exposed to larger amounts than adults in the same situations.

It is not known whether hydrogen sulfide can cause birth defects in people. Some animal studies have shown developmental problems from exposure to hydrogen sulfide.

How can families reduce the risk of exposure to hydrogen sulfide?

Families may be exposed if they live near natural or industrial sources of hydrogen sulfide such as hot springs, or pulp and paper mills. Families may want to restrict visits to these places.



Is there a medical test to show whether I've been exposed to hydrogen sulfide?



In case of life-threatening hydrogen sulfide poisoning, measurements of blood sulfide

or urinary thiosulfate levels may be used to confirm exposure. However, samples need to be taken within two hours of exposure to be useful.

Has the federal government made recommendations to protect human health?

EPA has established that hydrogen sulfide is a regulated toxic substance and is a hazardous substance as defined under the Federal Water Pollution Control Act.

  The Occupational Safety and Health Administration (OSHA) has established an acceptable ceiling concentration of 20 parts per million (20 ppm) in the workplace, with a maximum level of 50 ppm allowed for 10 minutes if no other measurable exposure occurs.

  The National Institute of Occupational Safety and Health (NIOSH) recommends a maximum exposure level of 10 ppm.

Source of Information

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for hydrogen sulfide. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

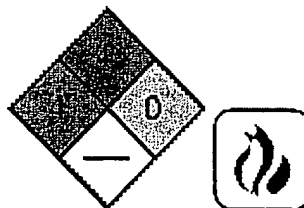
For more information, contact:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333
Phone: 1-888-422-8737
FAX: (404)498-0057

External safety and chemistry information (please see our [disclaimer](#)):

Hydrogen Sulfide
H₂S

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ATSDR Information Center / ATSDRIC@cdc.gov / 1-888-422-8737

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HYDROGEN SULFIDE GAS

This pamphlet provides answers to basic questions about **hydrogen sulfide** gas. It will explain what **hydrogen sulfide** gas is, where it is found, how it can affect your health, and what you can do to prevent or reduce exposure to it.

Hydrogen sulfide gas is also known as "sewer gas" because it is often produced by the decay of waste material. **Hydrogen sulfide** gas has a strong odor at low levels. At higher levels, your nose can become overwhelmed by the gas and you cannot smell it. At these higher levels, **hydrogen sulfide** gas can make you sick and even kill you.

WHAT IS HYDROGEN SULFIDE GAS?

Hydrogen sulfide gas has a strong odor that smells like rotten eggs. It is colorless and occurs naturally in the environment. **Hydrogen sulfide** gas can be formed and released whenever waste containing sulfur is broken down by bacteria.

Sewers, septic tanks, livestock waste pits, man holes, well pits, and trucks that transport chemical wastes may release **hydrogen sulfide** gas. **Hydrogen sulfide** gas also can be found in groundwater, especially in wells near oil fields or in wells that penetrate shale or sandstone.

Hydrogen sulfide gas also is found in petroleum and natural gas. Natural gas can contain up to 28 percent **hydrogen sulfide** gas so it may be an air pollutant near natural gas production areas and petroleum refineries. The gas also can be produced by industries that work with sulfur compounds.

HOW CAN I BE EXPOSED TO HYDROGEN SULFIDE GAS?

The main way to be exposed to **hydrogen sulfide** gas is by breathing it. You also can have skin or eye contact with **hydrogen sulfide** gas.

Exposure to **hydrogen sulfide** gas can occur in the home and in the workplace. In the home, exposure may occur because of faulty plumbing. Sewer drains that have dry traps can allow **hydrogen sulfide** gas to enter the home. Another common exposure is from well water that contains **hydrogen sulfide** gas. This water has the characteristic "rotten egg" smell. The unpleasant odor of well water does not usually signify a health hazard because the smell of **hydrogen sulfide** gas can be detected at low levels. Workers involved in occupations such as livestock farming, sewage treatment, and oil refining may be exposed to **hydrogen sulfide** gas at work.

HOW CAN HYDROGEN SULFIDE GAS AFFECT MY HEALTH?

Hydrogen sulfide gas can be smelled at a level of about 10 parts per billion (ppb). (A part per billion is about the same as a thimble full of **hydrogen sulfide** gas in a theater full of air.) Some people can smell it at even lower levels. Exposure to higher levels of **hydrogen sulfide** gas can irritate the eyes, the nose, and the lungs.

Although **hydrogen sulfide** gas has a strong odor, extended exposure deadens the sense of smell. At a level of 50 to 100 parts per million (ppm) of **hydrogen sulfide** gas in air, the sense of smell begins to break down. (A part per million is about the same as two soda cans full of **hydrogen sulfide** gas in a house full of air.) At this level, you should not rely on your sense of smell to decide if **hydrogen sulfide** gas is present. An instrument that measures **hydrogen sulfide** gas in air should be used.

As **hydrogen sulfide** gas levels increase, the gas can cause eye irritation, dizziness, coughing, and headache. At levels greater than 250 ppm, **hydrogen sulfide** gas begins to affect your ability to breathe. Exposure to more than 600 ppm can be rapidly fatal. Deaths have occurred when people have entered poorly ventilated spaces such as sewer systems, deep well pits, and underground liquid manure tanks. **Hydrogen sulfide** gas is heavier than air, so its concentration is usually highest near the bottom of these spaces.

→ At levels less than 250 ppm, recovery occurs quickly if exposure to **hydrogen sulfide** gas is ended promptly. Long-term nervous system problems have been found in survivors of short-term, high-level exposures. Some heart defects also have been reported in these cases.

In drinking water, a **hydrogen sulfide** gas concentration of 70 ppm may cause digestive system irritation. Drinking water containing 700 ppm of **hydrogen sulfide** is highly poisonous. Direct skin contact with water containing these levels of **hydrogen sulfide** gas can cause redness and pain. The eye can become irritated at low levels of **hydrogen sulfide** gas in water. Inflammation and permanent scarring of the eye can take place at very high levels.

It is not certain whether long-term exposure to low levels of **hydrogen sulfide** gas can make people sick. Studies with animals show that breathing low levels of **hydrogen sulfide** gas for a long time can cause irritation and inflammation of the nose, throat, and lungs. Other animal studies show that long-term exposure to low levels of **hydrogen sulfide** in drinking water can cause digestive system problems.

HOW CAN I REDUCE MY EXPOSURE TO HYDROGEN SULFIDE GAS?

Exposure to **hydrogen sulfide** gas can be reduced or prevented by ensuring that plumbing fixtures and pipes are installed and maintained properly. In homes where **hydrogen sulfide** gas is present you can reduce the level of the gas by locating and eliminating the source. Plumbers licensed by the Illinois Department of Public Health may be able to help with correcting problems associated with **hydrogen sulfide** gas. Increased ventilation in problem areas can temporarily reduce exposure to **hydrogen sulfide** gas.

Workers who may be exposed to **hydrogen sulfide** gas should follow the guidelines established by the U.S. Occupational Safety and Health Administration (OSHA). OSHA has established confined space entry standards to prevent death from exposure to chemicals like **hydrogen sulfide** gas.

WHERE CAN I GET MORE INFORMATION?

Illinois Department of Public Health
Division of Environmental Health
525 W. Jefferson St.
Springfield, IL 62761
217-782-5830
TTY (hearing impaired use only) 800-547-0466

U.S. Department of Labor

Occupational Safety and Health Administration (OSHA)

There are five regional OSHA offices in Illinois. Check your local telephone directory for the address and phone number of

the office nearest you.

This pamphlet was supported in part by funds from the Comprehensive Environmental Response, Compensation, and Liability Act trust fund through a cooperative agreement with the Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services.

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